Supporting Information

Tuning Charge Transfer Route by P-N Junction Catalysts Embedded with CdS Nanorods for Simultaneously Efficient Hydrogen and Oxygen Evolution

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Figure S1. XRD patterns of CdS Nrs and MoS$_2$/CdS/N-RGO hybrid.

The XRD patterns of the CdS Nrs and MoS$_2$/CdS/N-RGO hybrid have shown that the diffraction peaks match the standard peaks of hexagonal CdS with lattice constants of $a = 0.414$ nm and $c = 0.673$ nm (JCPDS card No. 41-1049). Magnification of the XRD pattern of MoS$_2$/CdS/N-RGO hybrid showed a diffraction hump at 14.2°, corresponding to the (002) MoS$_2$ plane.
**Figure S2.** SEM image of the MoS$_2$/CdS/N-RGO hybrid (a) and element mapping of the MoS$_2$/CdS/N-RGO hybrid (b).
Figure S3. Element mapping of the MoS$_2$/CdS/N-RGO hybrid in high resolution.
Figure S4. TEM and HR-TEM images of the type I MoS$_2$/N-RGO/CdS hybrid.

The SEM and TEM images of type I MoS$_2$/N-RGO/CdS hybrid show the topical morphology and it is noteworthy that the atom arrangement of CdS exhibits different lattice spacing, suggesting high degree of defect in CdS Nr.
Figure S5. TEM and HR-TEM images of the type II MoS$_2$/N-RGO/CdS hybrid.
Figure S6. XPS spectrum of the MoS$_2$/CdS/N-RGO hybrid, (b) High-resolution C1s XPS spectrum of the MoS$_2$/CdS/N-RGO hybrid, (c) High-resolution S2p and Mo3d XPS spectrum of the MoS$_2$/CdS/N-RGO hybrid, (d) High-resolution N1s and Cd3d XPS spectrum of the MoS$_2$/CdS/N-RGO hybrid.
Figure S7. TEM and STEM images of the N-RGO sheet.
Figure S8. SEM, TEM images and element mapping of the MoS$_2$/N-RGO hybrid.
Figure S9. The adsorption-desorption isotherms of pure CdS Nrs and MoS₂/CdS/RGO hybrid.
Figure S10. Potential variation of MoS$_2$/N-RGO during p/n junction formation process.
Figure S11. The transient photocurrent responses of MoS$_2$/N-RGO hybrid electrodes at 0.6 V vs Ag/AgCl in 1M NaOH aqueous solution under solar light irradiation. Notes that pure MoS$_2$ and N-RGO electrodes didn’t show photoresponse properties.
Figure S12. TEM images of the MoS\textsubscript{2}/CdS hybrid.

The CdS also has a strong emission at 518 nm which extends to 550 nm. This peak is attributed to the band-band PL phenomenon with the energy of light approximately equal to their band-gap energy. And a broad emission at 437 nm corresponds to the extrinsic deep-level emission.
Figure S14. EIS changes of CdS Nrs, type I MoS₂/N-RGO/CdS, type II MoS₂/N-RGO/CdS and MoS₂/CdS/N-RGO hybrid. The EIS measurements were performed in the presence of a 1 mM K₃[Fe(CN)₆]/K₄[Fe(CN)₆] (1:1) mixture as a redox probe in 0.5 M KCl aqueous solution.